



# Design Science Research

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# Lecturer

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## Consultation Hours:

Tuesdays 09:00 – 16:00 by appointment  
Thursdays 09:00 – 16:00 by appointment  
Email me though if you have other needs

# Introduction

- In this lesson I will introduce the Design Science Research (DSR) methodology
- I will be making heavy use of the following article which I invite you to also read for yourself and reference in your own study:

***Van der Merwe, A., Gerber, A., & Smuts, H. (2019). Guidelines for Conducting Design Science Research in Information Systems In: Liebenberg J., Gruner S. (eds) ICT Education. Communications in Computer and Information Science, vol 1136. Springer, Cham***

# Guidelines to students for using DSR

Van der Merwe et al. in [1] present six guidelines for students using DSR. These are:

1. Be able to contextualize DSR in the field
2. Understand the philosophy and discourse around DSR
3. Gain a historical perspective on DSR consulting seminal works
4. Understand the role of the artefact in DSR
5. Select an appropriate DSR method
6. Strategise on how research done will be communicated

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1. Contextualize DSR in the field

# Why Design Science Research?

- Aligns very well with systems design approach – formal steps you can follow to create an artefact to solve an identified problem.

# What is Design?

- Walls, Widmeyer and Sawy [2:36-37] define **design** as:

**“use of scientific principles, technical information and imagination in the definition of a structure, machine or system to perform pre-specified functions with the maximum economy and efficiency”**

- Design is both a **noun** and a **verb**

# What is Design Theory?

- Walls, Widmeyer and Sawy [2:36-37] define **design theory** as:

**“a prescriptive theory based on theoretical underpinnings which says how a design process can be carried out in a way which is both effective and feasible”**

- This is **how** you will be doing things.



# What is Design Science Research?

- Hevner et al. indicates that **DSR** is a **paradigm** where:  
“knowledge and understanding of a problem domain and its solution are achieved in the building and application of the designed artefact”
- Viashnavi, Keuchler and Petter define:  
“DSR as being involved in the creation of new knowledge, firstly through the development of artefacts and secondly through the study of the use of the artefact afterwards”

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# Paradigm or approach?

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# Paradigm or approach?

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“knowledge and understanding of a problem domain and its

This is not the only way to view DSR. Van der Merwe et al. present three possible views that have been presented in the literature over time:

- **DSR as a paradigm**
- **DSR as an approach within traditional positivistic/interpretive paradigms**
- **DSR as an approach with a pragmatic philosophy**

DSR as being involved in the creation of new knowledge, firstly through the development of artefacts and secondly through the study of the use of the artefact afterwards”

# DSR as Paradigm

Ontology	Epistemology	Methodology	Axiology
Multiple, contextually situated alternative world-states. Socio-technologically enabled	Knowing through making: objectively constrained construction within a context. Iterative circumscription reveals meaning	Developmental. Measure artefactual impacts on the composite system	Control; creation; problem-solving; progress (i.e., improvement); understanding

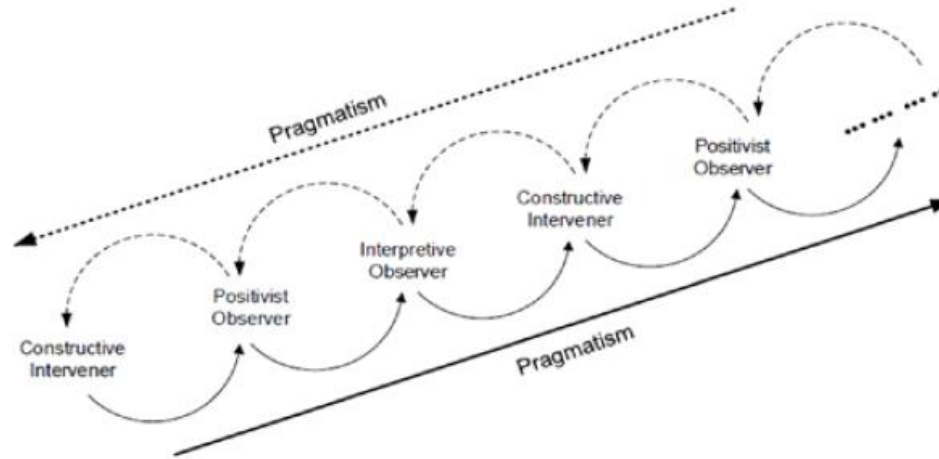
Vaishnavi, Keuchler and Petter in [8], summarised by Van der Merwe in [1] argue for design as a paradigm as it changes the world through the development of new artefacts.

# DSR in other paradigms

Gregory in [9] claims DSR as being conducted in a largely **positivistic** way, with Venable proposing that DSR is done with the focus on theory building in a **positivist** or **interpretivist** way in [10]. This is DSR as **Method** in other paradigms.

Carlson in [11] proposes a philosophy of **Critical Realism** to:  
“recognize the reality of the natural order and the events and discourses of the social world. It holds that we will only be able to understand—and so change—the social world if we identify the structures at work that generate those events or discourses”

# Pragmatic paradigm with a DSR approach



Deng and Ji [6] highlight DSR as having a pragmatic philosophy while having the researcher go through different phases as they become useful during the course of the research.

# Pragmatic paradigm with a DSR approach

My recommendation is to stick with DSR as your methodology with pragmatism as your paradigm as claimed by Hevner in [7]

**A. R. Hevner, “A Three Cycle View of Design Science Research”, *Scandinavian Journal of Information Systems*, 19(2), pp. 87–92, 2007.**



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# Seminal works and authors

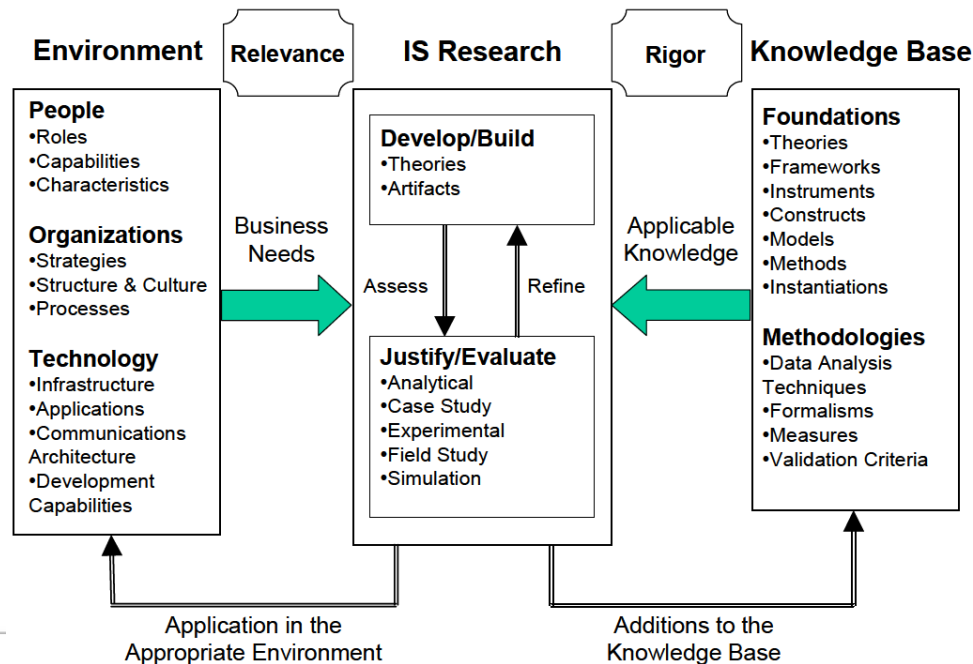
Van der Merwe et al in [1] presents a concise history of DSR with the work of Hevner et al in [3] from 2004 used as reference point.

**Table 4. Seminal works in DSR [18]**

Reference	Cita- tions	Year	Significance
March et al. [10]	3 979	1995	Initially proposed types of artefacts
Walls [2]	1 530	1992	Focuses on design theory - Provides a method for theory building;
Nunamaker et al. [27]	1 508	1991	Proposes a method – argues from the system development background for design
Gregor and Jones [28]	1 428	2007	Focuses on design theory; distinguishes between two different kinds of purposeful artefacts that can be designed: product artefacts and process artefacts.
Gregor and Hevner [29]	1 402	2013	Overview article; positions DSR; gives guidance on publishing DSR;
Cross [19]	1 306	2001	Nature of DSR, distinguishes between scientific design, design science, a science of design
Markus et al. [30]	1 282	2002	Example of a design theory for knowledge management processes

# Seminal works and authors

Arguably, Hevner et al [3] is the paper that started the serious work in DSR as a recognised methodology in IS research.



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**ALL of these are examples of artefacts**

# What is an artefact?

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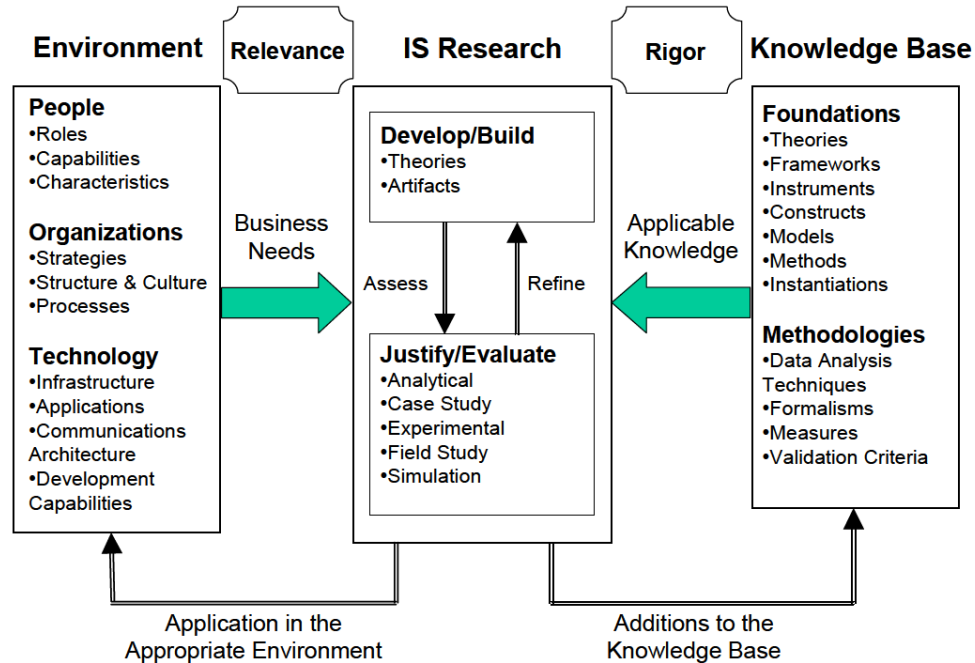
- What is less clear is whether **design theory** should be an artefact – here the literature has conflicting guidance.
- That said, some amount of theorising about the design theory you followed is expected in a DSR study.
- You should be cognisant of your design and theories that emerge as you develop your artefact – research questions can emerge during your study!

# Guidelines to students for using DSR

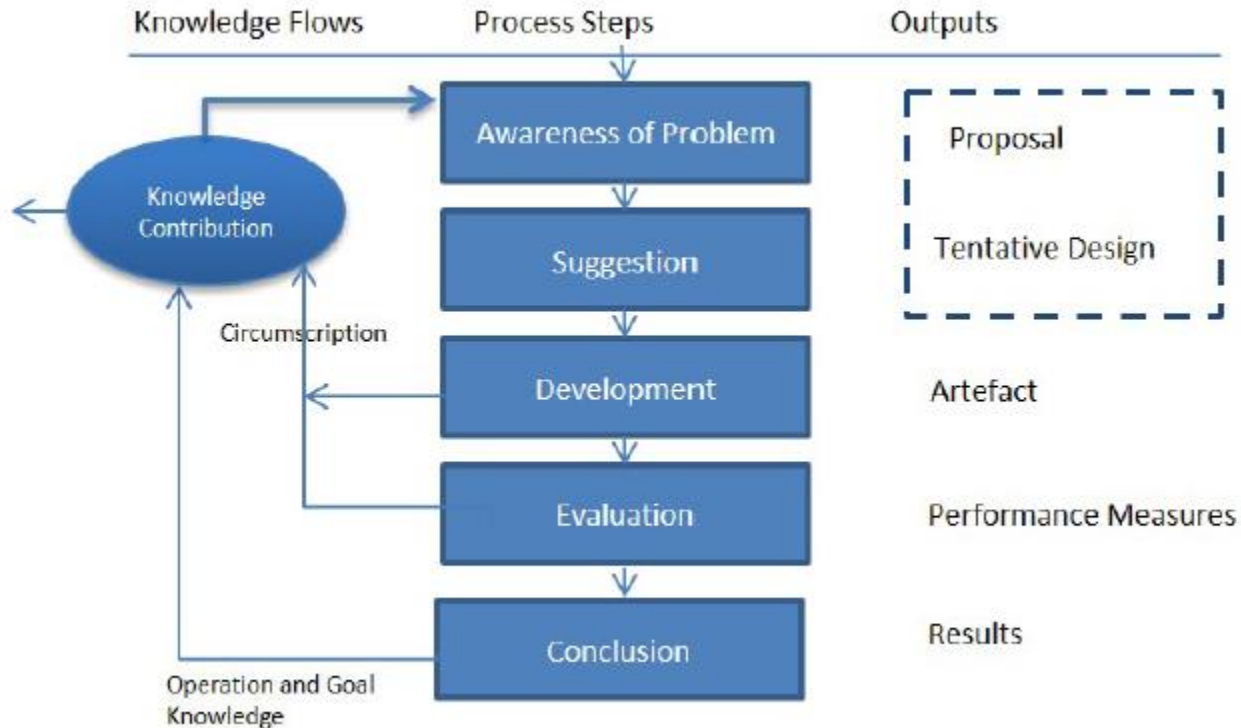
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# Hevner et al. model in [3]

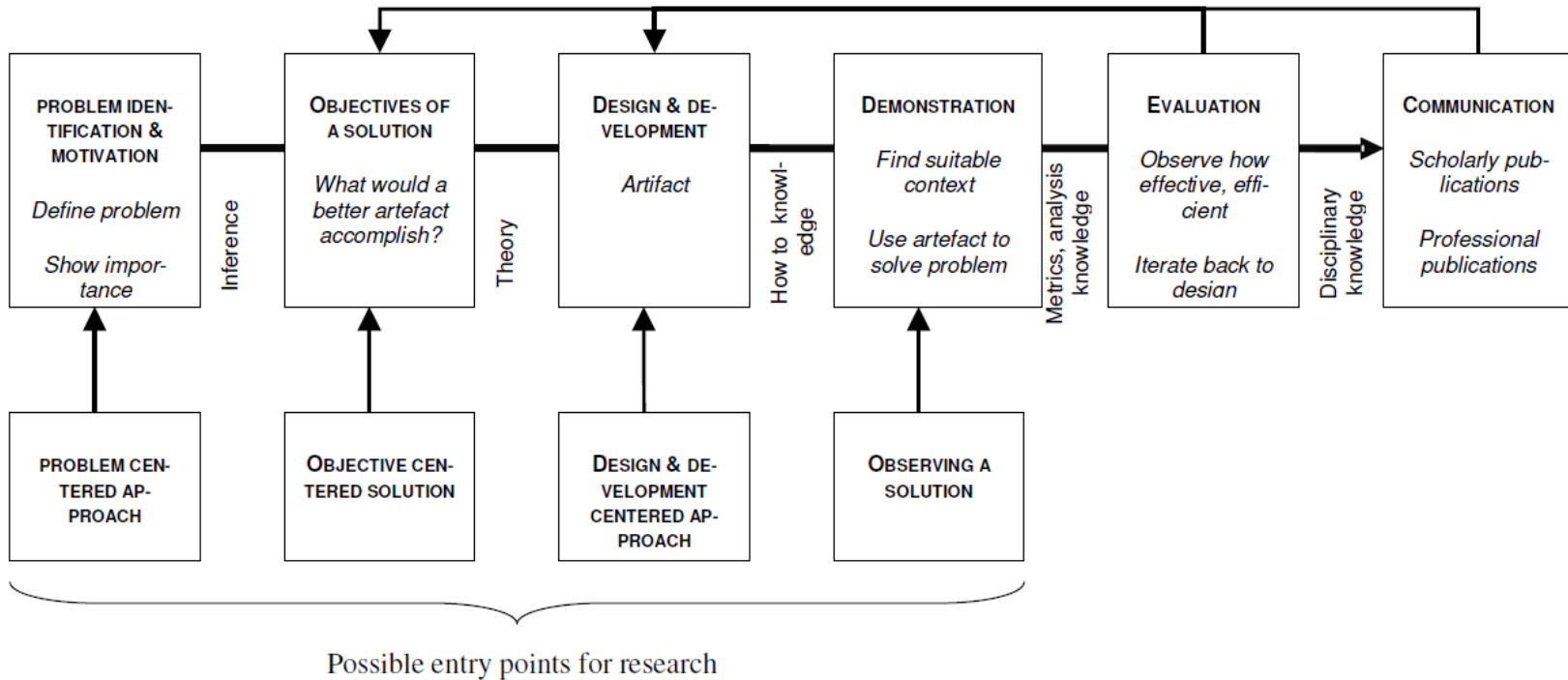


# Vaishnavi et al. model in [4]



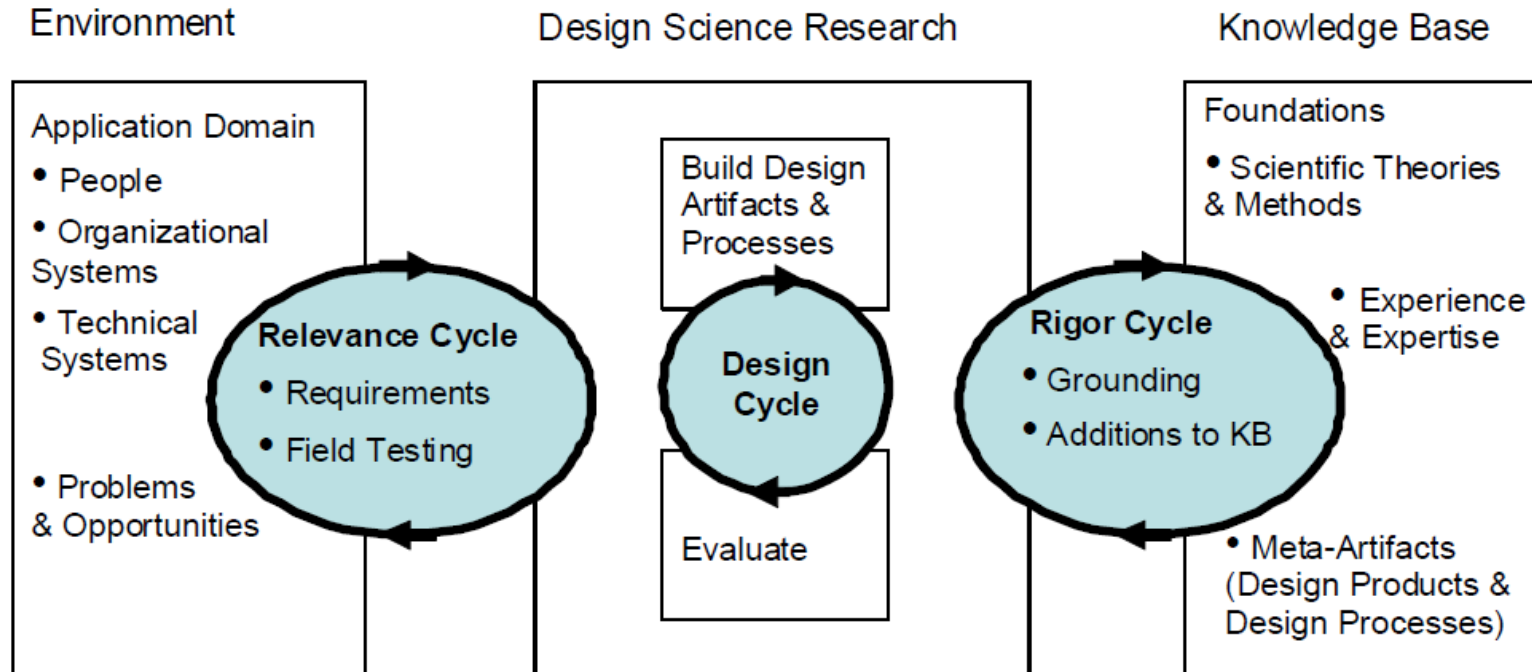
# Peffers et al. model in [16]

Nominal process sequence





# Hevner et al. three cycle view in [7]



# Peffers et al. Evaluation in DSR in [17]

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Logical Argument	An argument with face validity.
Expert Evaluation	Assessment of an artifact by one or more experts (e.g., Delphi study).
Technical Experiment	A performance evaluation of an algorithm implementation using real-world data, synthetic data, or no data, designed to evaluate the technical performance, rather than its performance in relation to the real world.
Subject-based Experiment	A test involving subjects to evaluate whether an assertion is true.
Action Research	Use of an artifact in a real-world situation as part of a research intervention, evaluating its effect on the real-world situation.
Prototype	Implementation of an artifact aimed at demonstrating the utility or suitability of the artifact.
Case Study	Application of an artifact to a real-world situation, evaluating its effect on the real-world situation.
Illustrative Scenario	Application of an artifact to a synthetic or real-world situation aimed at illustrating suitability or utility of the artifact.

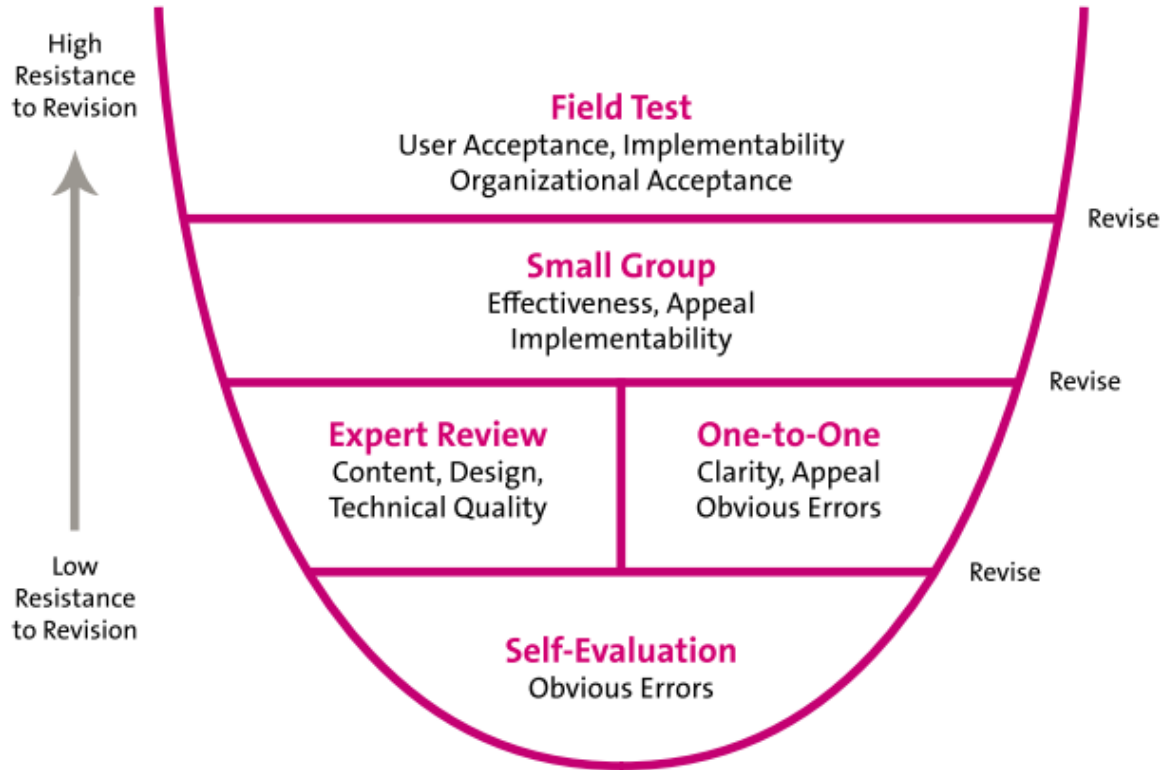
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# Peffers et al. Evaluation in DSR in [17]

**Table 4.** Distribution of Evaluation Methods by Artifact Type (all journals)

	Logical Argument	Expert Evaluation	Technical Experiment	Subject-Based Experiment	Prototype	Action Research	Case Study	Illustrative Scenario	none	Total
Algorithm	1		60	1				3		65
Construct	3		3	2	2			2		12
Framework	1	1			1		1	4	1	9
Instantiation			5	1	1			1		8
Method	2		14	4			7	6		33
Model	3		10		2	2		4		21
Total	10	1	92	8	6	2	8	20	1	

# Nieveen on Evaluating Prototypes (EDR) in [18]



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		Development or prototyping phase						
Stages in → prototype development		preliminary computer- based version	paper-based version		computer-based versions		final version	
		Users (n=5)	experts (n=3)	users (n=5)	experts (n=6)	users (n=4)	users (n=4)	users (n=17)
Validity	content *)		√ ea		√ ea			
	interface				√ ea			
Practicality	content	√ wt		√ wt	√ ea	√ me	√ to	√ ft
	interface	√ wt		√ wt	√ ea	√ me	√ to	√ ft
Effectiveness	entire system						√ to	√ ft

\*) : Content refers to the content of the support system

√ = primary attention of prototype and of formative evaluation

Methods of formative evaluation: me = micro evaluation; wt = walk through; ea = expert appraisal;  
ft = field trial; to = try-out

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Validity	content *)		√ ea		√ ea			
	interface				√ ea			
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Efficacy,  
Ethics,  
Elegance?

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## Example:

Phase	Cycle	Iteration	Developer	Evaluation	Expert	Analysis	Small	Group	Field	Trial	#Students	#Study	Leaders	Course	Coordinator	Engineering	Education	Content	Expert	Senior	Academic	Psychology/	Engagement	Number of	Participants
Needs and Context Analysis	Initial Litt. Review and needs Analysis	1	X	X													X							2	
		2		X	X											X	X							3	
		3	X																						1
	Trial Prototype (Education)	1	X	X										X				X							2
		2	X					X	X (65)	X(8)	X	X	X	X	X	X	X	X	X	X	X				
Design, Development and evaluation of prototypes	Prototype 1	1	X	X									X	X	X	X	X	X	X	X					4
		2	X	X	X (AR)												X	X							4
		3					X	X(89)	X(20)	X	X	X	X	X	X	X	X	X	X	X					113
	Prototype 2	1	X	X														X	X						3
		2	X		X (AR)				X(105)	X(21)	X	X	X	X	X	X	X	X	X	X					126
		3	X	X									X		X	X	X	X	X	X					2
		4	X		X	X	X	X(105)	X(21)	X	X	X	X	X	X	X	X	X	X	X					126
	Prototype 3	1	X	X										X	X	X	X	X	X	X	X				4
		2		X	X	X	X	X(113)	X(19)	X	X	X	X	X	X	X	X	X	X	X					133
	Prototype 4	1	X	X														X				X			2
2		X				X	X(51)										X				X			53	
3		X	X			X	X(24)										X				X			26	
Semi-Summative Evaluations	Final Evaluation	1	Final Review and Handover, Reflections in Chapter 7																						
	Results publication	2	Thesis, 2x EDUCON 2018 Papers, 2x SASEE 2017 Ext Abstracts, 2x Journal Paper (In Progress)																						

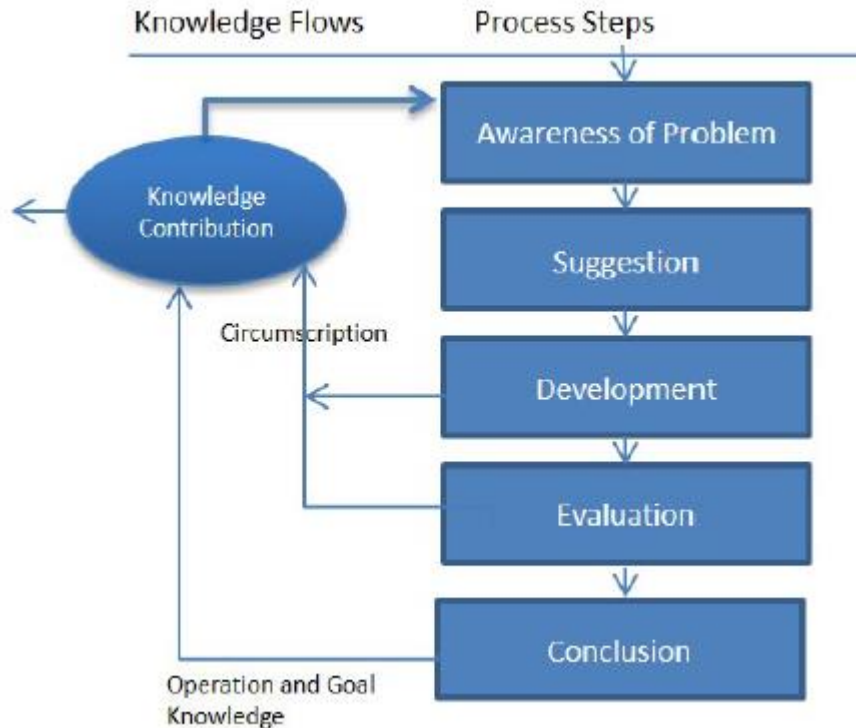
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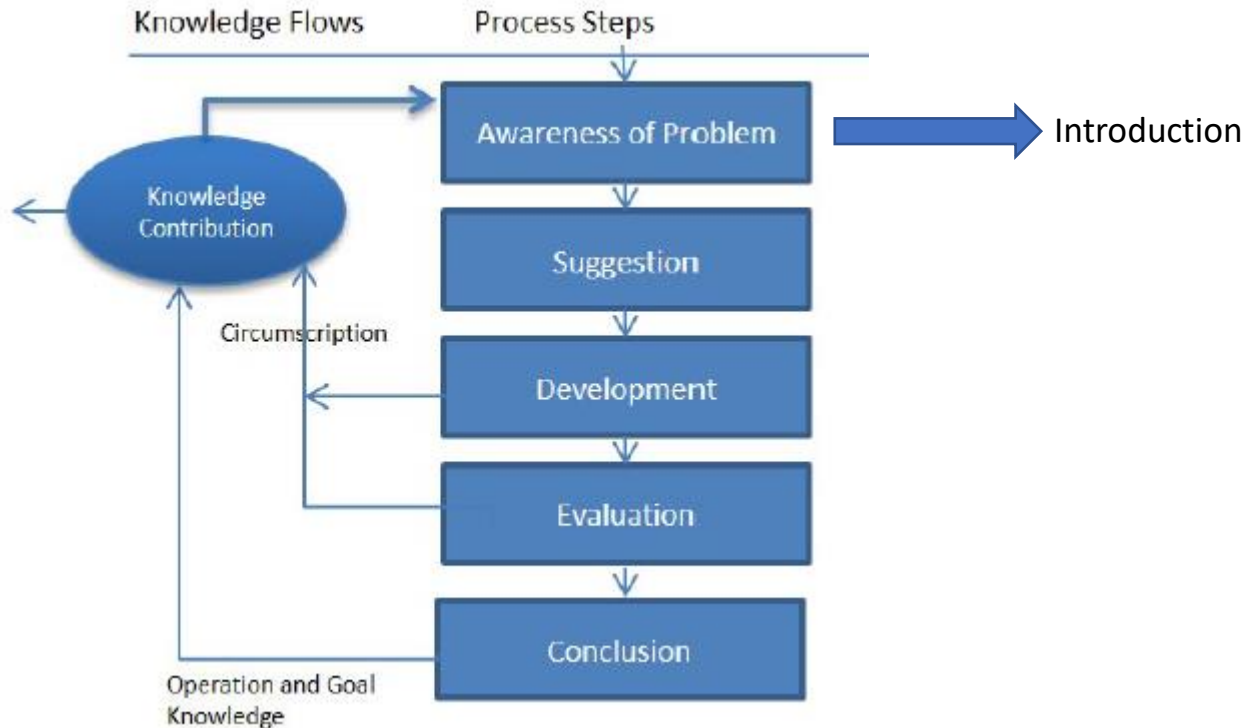
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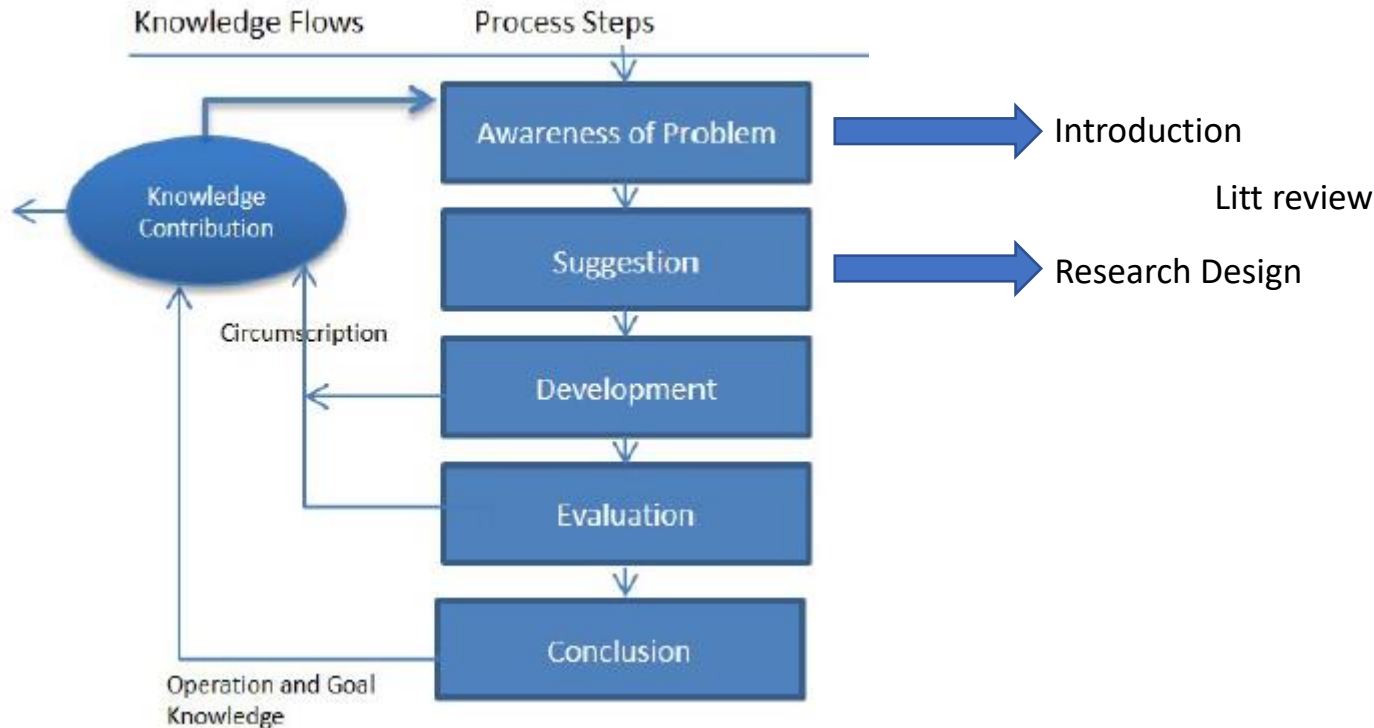
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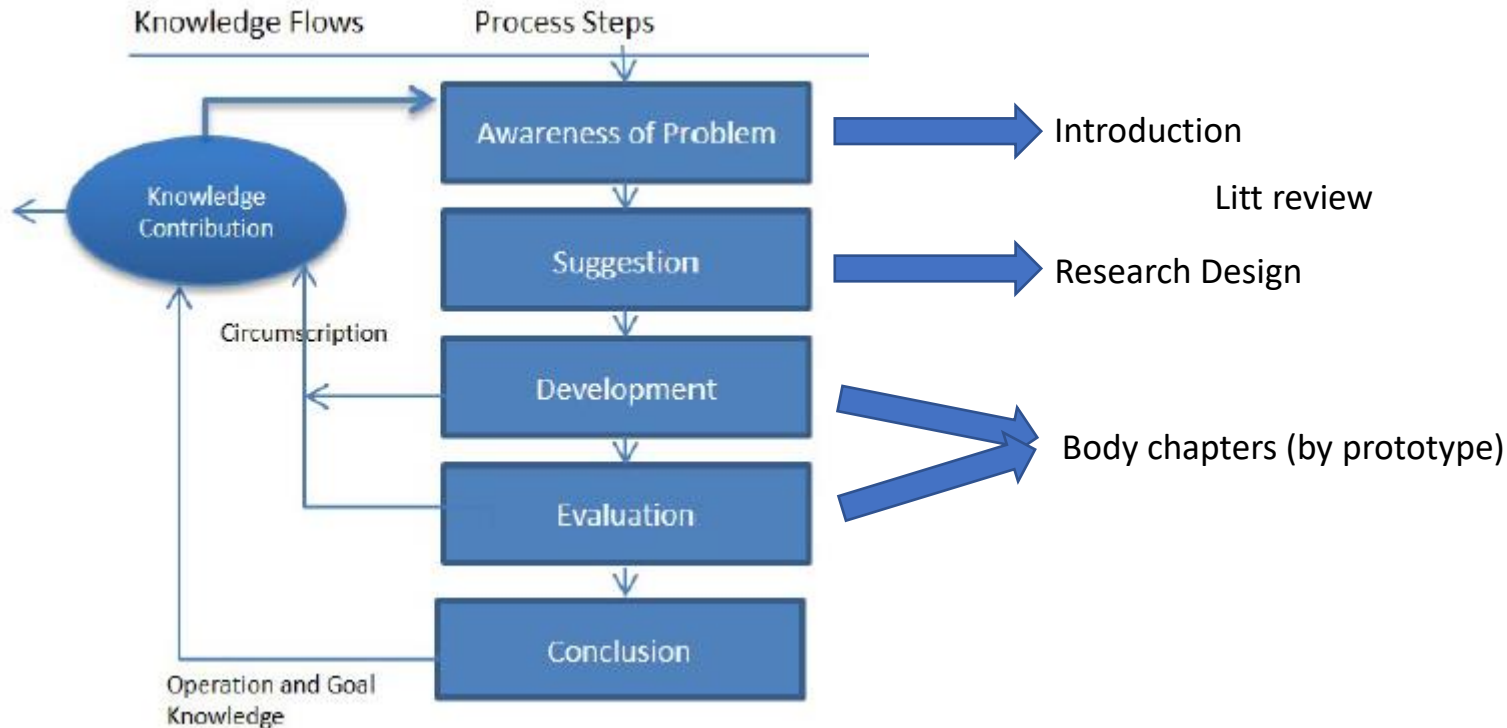
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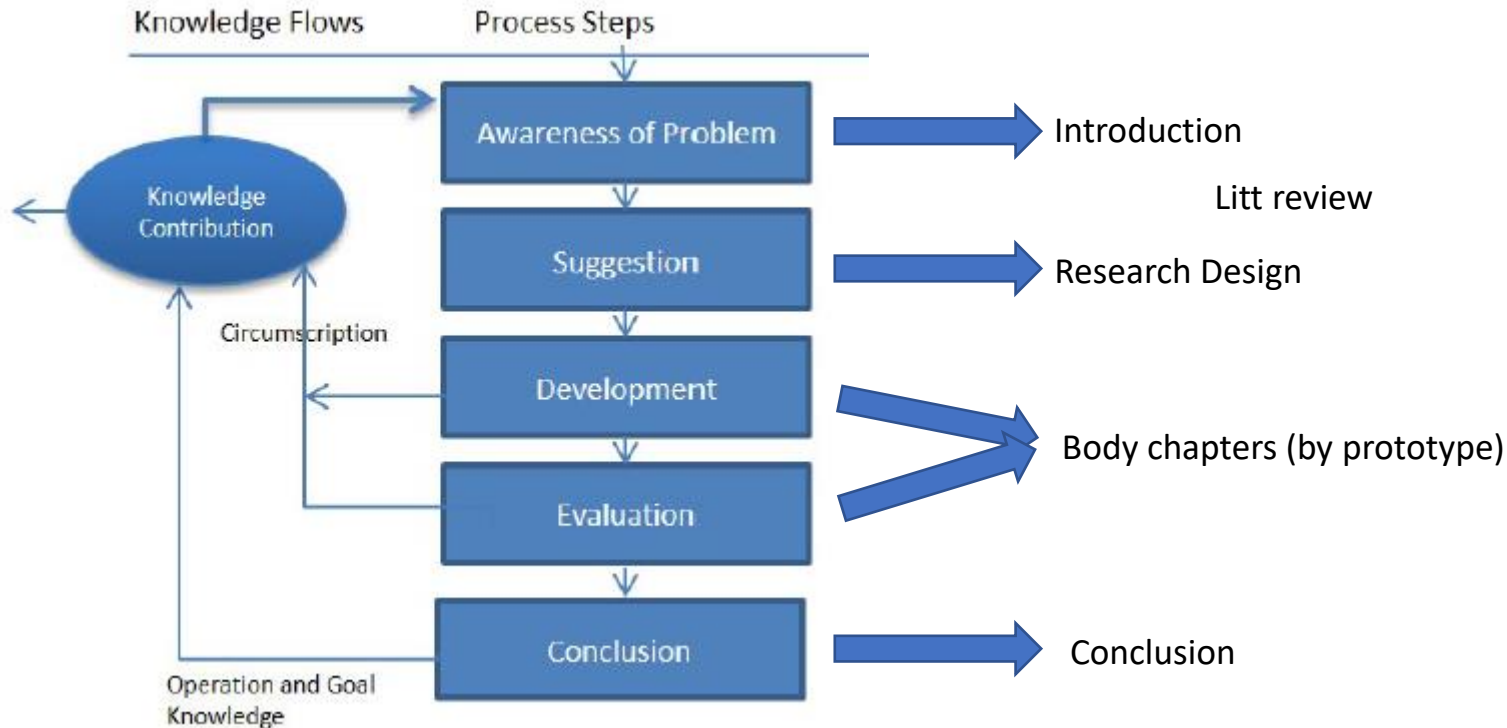
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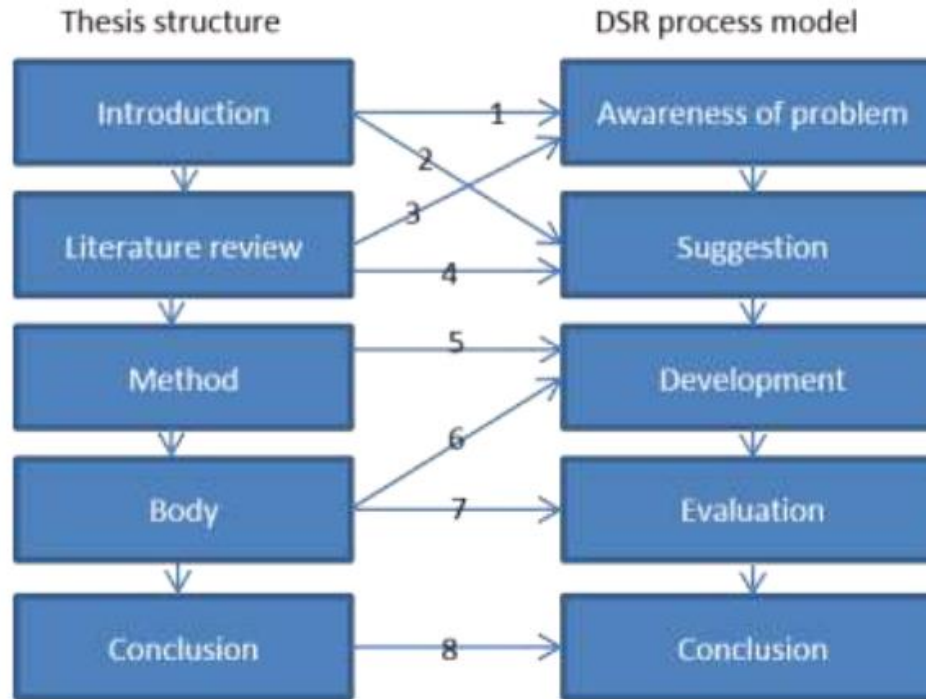


Figure 5: Mapping for a single design science research process cycle.

# Conclusions

- DSR has become a common and accepted research methodology in IS, as well as in education, engineering etc.
- Multidisciplinary evaluation could lead to interesting design theory contributions
- The iterative nature of DSR works well from a project roll out point of view
- Parallel models can be run on the same data – development and research running in tandem!

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# Thank you!

## Questions and Discussion...